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Fabrication of Miniaturized Shadow-mask for Local Deposition

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ABSTRACT

A new tool of surface patterning technique for general purpose lithography was developed based on shadow mask method. This paper describes the fabrication of a new type of miniaturized shadow mask. The shadow mask is fabricated by photolithography and etching of 100-mm full wafer. The fabricated shadow mask has over 388 membranes with apertures of micrometer length scale ranging from 1 μm to 100s μm made on each 2mm x 2mm large low stress silicon nitride membrane. It allows micro scale patterns to be directly deposited on substrate surface through apertures of the membrane. This shadow mask method has much wider choice of deposit materials, and can be applied to wider class of surfaces including chemical functional layer, MEMS/NEMS surfaces, and biosensors.

Key Words : Shadow mask (), Microfabrication (가), Evaporation (), Micropatterning (), MEMS ()

1. (nanostructures) 가 .
가 가 ,
UV (UV photolithography) (substrate) .
(UV light) NEMS/MEMS,
가 (polymer based device), (micro-fluidics),
MEMS (bio-analytical systems)
, 가
UV (surface modification)
/ 가 .
가 .
Deep UV, (X-ray), 가 .
(e-beam) 가

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(membrane) 1-4
(deposition) ,
(Fig. 1).
(exposure) (spin coating),
(deposition) (development),
(lift-off)
(electroforming), (etching),
(laser cutting) 가 ~100 μm

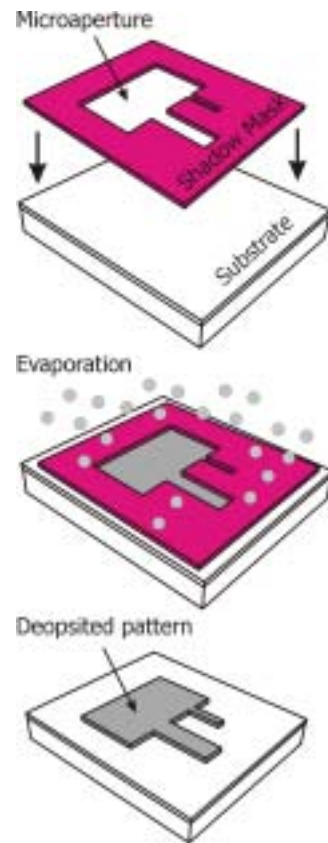


Fig. 1 Schematic diagram of shadow masking principle

MEMS
Si, SiO₂
가
SiN
10-100 nm 가 μm^2
(high-throughput)
100 mm 가 (micro machining)
2x2 mm² 388 가

2.

2.1

100 mm 가 (micro-fabrication) 8

Fig. 2

(double polished)
(low-stressed SiN)
(100)
100 mm, 380 μm
SiN 500 nm , LPCVD (low pressure
chemical vapour deposition)
SiN 200 MPa

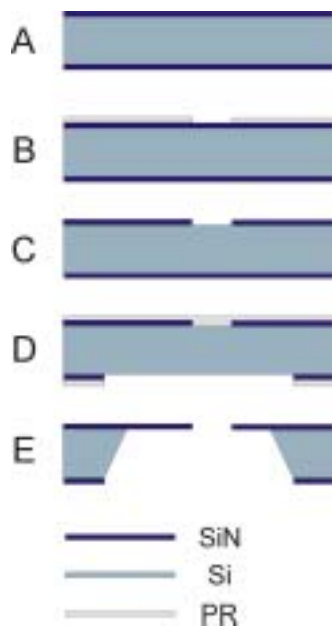


Fig. 2 Process overview of shadow mask fabrication: (a) SiN layer deposition (b) aperture patterning by photolithography (c) pattern transfer into SiN layer on top (d) membrane window definition by photolithography on backside (e) bulk Si wet etching to make membrane

(photo-resist, S1818, Positive type, Shipley) 5000 rpm
1.7 μm 115°C 45
(soft-baking, 50 μm proxy) . MA-
150 aligner (Karl Suss, UV lamp 1000W Hg) 8
(exposure) (developing)
(Hard baking, 90 sec, 115°C, 50 μm proxy) RiteTrack
Developer
ICP (inductively coupled plasma) etching
SiN (anisotropic etching)
SiN
(601E, Alcatel : C_2F_6 20 sccm, 20°C, 1800W).
SiN
KOH
(40% wt, 60°C) (bulk silicon etching)
SiN

1% HF 가
(natural oxide) . KOH
Si (etching rate) 18.7 $\mu\text{m/hr}$
Si (metal chuck)
, RCA2 (cleaning)

2.2

Fig. 3

100-mm
Fig. 3(a) 100-
mm
388
2 mm x 2
mm, 500 nm (rim)
Fig. 3(b)
(SEM, scanning electron microscopy)

Fig. 3 (c)

SEM
1 μm

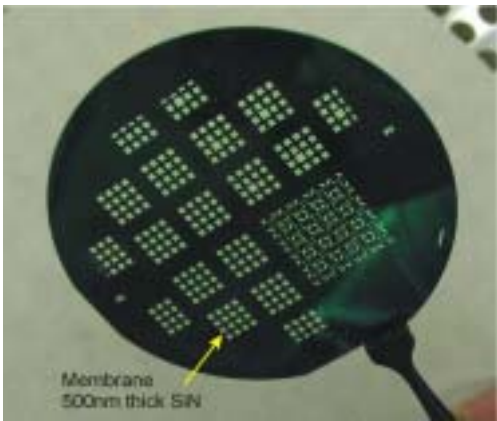
3.

(vacuum chamber)

(e-beam evaporation) (EVA 600,
Alcatel, base chamber pressure 5×10^{-7} mbar). Fig. 4
SEM

5 μm (proximity)

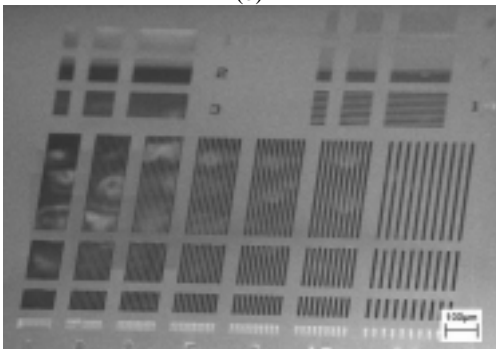
(shadow effect)



(a)



(b)



(c)

Fig. 3 SEM images of a fabricated micro-shadowmask: (a) full wafer scale shadow mask, (b) image taken from the backside of shadowmask. (c) close-up image of a membrane pattern.

. Fig. 5(a)
SEM

(atomic force microscope, AFM)
(topography)
AFM Nanosurf EasyScan . Fig. 5(b)
AFM
(blur)

가

40nm

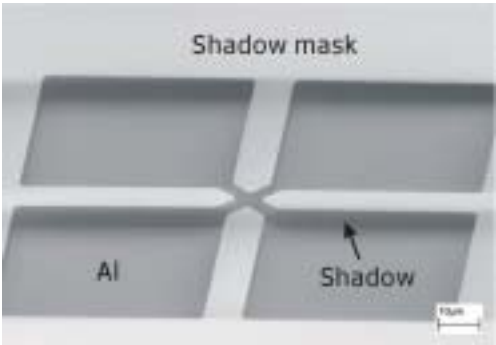


Fig. 4 SEM image of shadowmask and surface after evaporation of 100-nm-thick Al layer

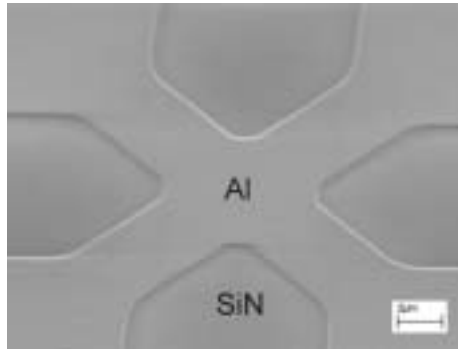
4.

100 mm 388
가
2mm x
(Low stressed SiN)

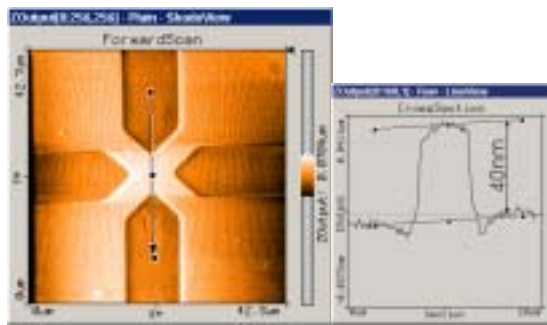
SEM, AFM
가

가 가 ,

가 .



(a)



(b)

Fig. 5 (a) SEM image of micro scale pattern made by shadowmasking. (b) AFM image and surface profile of deposited pattern

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